The following table gives the means and departures for each April from 1897 to 1911, inclusive:

Years.	Mean.	Departure.	Years.	Mean.	Departure.
	°F.	°F.		°F.	°F.
1897	60.6	+4.5	1905	57.2	+1.1
1898	60.9	+4.8	1906	56.3	+0.2
1899	58.1	+2.0	1907	58.2	+2.1
1900	53.9	−2.2	1908	58.4	+2.3
1901	55.8	−0.3	1909	57.6	+1.5
1902	56.2	+0.1	1910	59.8	+3.7
1903	54.8	−1.3	1911	54.2	−1.9
1904	57.2	+1.1			

The highest temperature reported at any station was 97° at Orleans on the 23d. This was 13° lower than the highest recorded in April, 1910. The lowest temperature at any station during April, 1911, was −2° at Summit on the 12th, which was 11° colder than the lowest recorded during April, 1910.

PRECIPITATION.

The average monthly precipitation for the State was 1.93 inches.

The following table gives the average and departure from the normal for each April from 1897 to 1911, inclusive:

Years.	Mean.	Departure.	Years.	Mean.	Departure.
	Inches.	Inches.		Inches.	Inches.
1897	0.51	−1.61	1905	1.18	−0.94
1898	.41	−1.71	1906	1.68	− .44
1899	.60	−1.52	1907	1.11	−1.01
1900	2.14	+ .02	1908	.67	−1.45
1901	2.16	+ .04	1909	.12	−2.00
1902	1.88	− .24	1910	.62	−1.50
1903	1.28	− .84	1911	1.93	− .19
1904	2.18	+ .06			

The greatest monthly rainfall was 8.65 inches, at Inskip. At 7 stations no rainfall was reported. The distribution of the rain geographically was far from uniform. The mountain sections had most of the rain. With regard to time distribution the period between the 5th and the 12th was the one in which most of the rain fell. The greatest 24-hour rainfall was 6.30 inches at Magalia, Butte County, on the 4th. Other heavy rainfalls were 4.55 inches at Nimshew, 4.25 at Inskip, and 4.15 inches at Branscomb.

Snowfall.—The month was one of more than average snowfall. There was a great deal more snow than for several Aprils past. The snow cover, which was unusually deep at the beginning of the month, increased slowly until about the 12th, and then steadily diminished until the end of the month. After the first decade there was a fairly uniform rate of melting of about 4 inches a day at elevations of from 5,000 to 7,000 feet. At the close of the month the snow cover was both extensive and deep, giving every indication of an abundant supply of water for the summer months.

SUNSHINE.

The following table gives the total hours of sunshine and percentages of the possible:

Stations.	Hours.	Percentage of possible.	Stations.	Hours.	Percentage of possible.
Eureka	192	48	Sacramento	279	70
Fresno	317	80	San Diego	244	62
Los Angeles	214	55	San Francisco	233	59
Mount Tamalpais	299	76	San Jose	284	72
Red Bluff	297	74	San Luis Obispo	251	64

EARTHQUAKES.

Earthquakes were reported at Brawley, 26th, 28th; Point Loma, 28th; at Santa Clara, 6th, 11:49:36 p. m., period 1 second, origin 110.7 kilometers southeast; 10th, 10:51:15 a. m., period 1.5 seconds, origin 190.7 kilometers west, 30° 58′ N., small tremors all day; 24th, 10:26:24 p. m., period 6 seconds, origin 157 kilometers east, 24° 21′ N., light shock felt; 28th, 2:01:52 a. m., period 1 second, origin 212.5 kilometers west, 42° 16′ N., second shock, 2:10:01 a. m., ended 2:11:30 a. m., many small tremors during day.

Berkeley: 19th, 12:20:19 p. m. Perceptible motion ended 12:23:05 p. m. The shock was very feeble, but was sharply marked on the seismogram. It originated at a distance of about 24 miles south-southeast from Berkeley. Magnified 80 times the earth motion (double amplitude) reached a maximum value of 1.75 millimeters. The second shock, a trifle feebler than the first, occurred at 9:40:48 p. m. Origin about 25 miles south-southeast. The third shock at 4:39:02 a. m. Direction and distance of the origin could not be determined. 21st, 6.45 p. m., feeble and no estimate of direction or distance can be made. 25th, a near shock at 10:27:24 p. m., with a magnification of 80 times a maximum earth shift of 2.5 millimeters was registered in the north-south direction and 2.25 millimeters in the east-west direction. The origin lay to the south at a distance of about 180 miles. 28th, 2:02:16 a. m., origin 1,700 miles from Berkeley; direction uncertain. The shock is feebly recorded here, indicating that it had no great strength at origin. The maximum earth shift registered was 1.5 millimeters, magnification 80.

Eclipse.—A partial eclipse of the sun was noted at San Francisco on the 28th, beginning about 3.05 p. m. and ending about 4.36 p. m. At San Diego the observer states that the moon's shadow caused an interruption of the record on the sunshine recorder between 3.53 and 4.07 p. m. Shortly after the eclipse afternoon clouds began to form. At Eureka a partial eclipse was observed at 3.50 p. m., at which time one-sixth of the sun's disk was dark; owing to cloudiness the beginning was not observed, but the last contact occurred at 4.24 p. m.

NOTES ON THE RIVERS OF THE SACRAMENTO AND SAN JOAQUIN WATERSHEDS DURING THE MONTH OF APRIL, 1911.

By N. R. TAYLOR, Local Forecaster.

Sacramento watershed.—While much less than the usual amount of rain fell during the month, all streams in this watershed carried more water than for any April since that of 1907, the year of the big flood.

Snow water was the controlling factor in the run-off of all watercourses, there being more snow on the ground in the high Sierras during April than for any corresponding month in many years. In the Feather-Yuba River system all streams were practically bank full during the entire month, and in some cases, notably, that of the Middle Fork of the Feather, freshets occurred.

The Sacramento River, below Knights Landing, averaged higher than for any month since that of February, 1909.

The American River was unusually full, being over 1 foot above the normal for the month and over 2 feet above the average stage usually maintained during the rainy season.

It is estimated that there was from 1 to 2 feet more water in the flood basin of the Sacramento River at the close of April than there was at the same time last year.

San Joaquin watershed.—The river stages of this watershed averaged much above the normal for the month, and all streams carried more water than for any April since that of 1907.

FROST FIGHTING IN CALIFORNIA VINEYARDS.

By W. E. BONNETT, Local Forecaster.

On April 13 this section was visited by one of the most damaging frosts that has occurred here for many years. Reports as to the aggregate damage are necessarily somewhat conflicting, and its extent will probably not be definitely known for many weeks, but the injury to raisin and wine grapes is likely to be between 40 and 50 per cent of an average crop. As is the case with most fruits, many varieties of vines do not recover when the first tender shoots have been frozen, and the crop for the season is lost. However, a few varieties do put forth new fruit buds after the first growth has been killed and these produce a somewhat later and lighter yield. This circumstance makes early estimates of the ultimate damage more uncertain.

A review of the meteorological conditions leading up to this frost may be interesting. High barometric pressure over the North Pacific States and persistent low pressure over southern California and Arizona resulted in desiccating northerly winds during the 11th and 12th. A damaging frost on the former date was prevented only by the considerable wind movement which continued during the night. At 5 p. m. of the 11th the dewpoint was 30° and the relative humidity 34 per cent. At 5 p. m. of the 12th, after another 24 hours of dry northerly winds, the dewpoint was 16° and the relative humidity 18 per cent. On but one other occasion in our record of April frosts has the atmospheric moisture been so low, on April 4, 1895, and this was followed by a killing frost next morning. Owing to the extreme dryness of the air there was very little actual frost, absolutely none where the damage was severe, and the resulting phenomenon was what is often popularly spoken of as a "black frost," a name for the effect rather than the name of the phenomenon itself.

Warnings of a severe frost had been issued on the morning of the 12th, and upon the kind invitation of Mr. George C. Roeding, a prominent nurseryman and fruit grower, I spent the night of the 12th and 13th at his country home, about 8 miles east of Fresno, to witness an experiment in frost fighting. He had provided fire pots and materials for firing in 30 acres of a 130-acre vineyard of Thompson Seedless grapes, and his experiment is probably the first systematic attempt at frost fighting in the vineyards of this locality. The results were pleasing to him, and they will be generally instructive to grape growers.

No opportunity was offered for securing the instruments necessary to a proper history of the experiment; we had no thermograph and not enough thermometers, but the thermometers we had, all belonging to Mr. Roeding, had been compared with the instruments in the local office of the Weather Bureau, and I can personally vouch for their accuracy. Upon arising at 2 a. m. it was found that the temperature had fallen to 32° and the fires were lighted as quickly as possible. Thirty fire pots to the acre were used, and they were charged to about one-half of their capacity with 8 pounds of a specially prepared fuel of sawdust and shavings, saturated with crude oil. Soon after 3 o'clock all fires had been lighted. Two thermometers were placed in different parts of the vineyard on the trellis and about 3 feet above the ground; one was placed to the west, the windward side, another about 50 yards south from the vineyard. A minimum thermometer was left at the ranch office, perhaps one-eighth of a mile from the fires. An examination of this instrument at 5 o'clock showed a minimum of 27°. From 3.30, when the effects of the firing were becoming apparent, until 6 a. m., the temperature in the vineyard fluctuated between 32° and 35°. The temperatures shown by thermometers outside of but quite near to the vineyard ranged between 29° and 31° during the same time, but I believe they were too close to the vineyard to give the minimum that would have been reached in undisturbed air. The heat from the fires induced a gentle indraft of air toward the vineyard, and this caused sufficient mixing near its borders to prevent the occurrence of a minimum as low as that shown by the thermometer entirely removed from any effect of the heating.

Now, it will be observed that the increase in temperature produced by this firing was not great, but the vineyard shows no injury while near-by vineyards similarly located suffered serious damage. This emphasizes the fact that the thermal margin between freezing and nonfreezing was very small. The fact that this difference is very small, a difference that should be overcome with comparative ease by smudging or firing, is further emphasized by many peculiarities in the distribution of the damage. It is found that the frost, although fairly general, has wrought injury in its customary freaky fashion. It may be pointed out that the major portion of the grapes here are grown on a practically level plain many miles from the foothills, most of them from 10 to 30 miles and more, and that the differences in elevation within short distances, say for example, from vineyard to vineyard, are quite small. However, these small differences in elevation have meant in many cases the difference between injury and immunity; in other cases the vineyards into which the irrigation waters had been turned were saved; in still other cases recent cultivation or the lack of it seems to have made a difference in the extent of damage. All of this shows that the danger lies within very narrow temperature limits.

It is not often that frosts occur which are generally damaging to the grapes of this locality, and the preparations for an annual warfare against it, so necessary in less-favored sections, are not required here, but a series of favorable seasons begets a feeling of security on the part of the growers and the protective measures that might be easily applied are not used.

The absolute minimum for April at this station is 34°, and this has been reached in 6 Aprils of the last 24, but damaging frosts occurred on but two or three of these occasions. The low temperatures of the remaining occasions came in conjunction with other conditions of wind, weather, or moisture which prevented frost. It should be pointed out that this record is from a roof exposure of thermometers that has varied from 36 to 67 feet above the ground since the establishment of the station. On the occasion under discussion reliable instruments exposed near the ground in various places in the vicinity of Fresno recorded minimum temperatures of 27° and 28° as against our 34°, and on a quiet night 6° probably represents the amount of temperature inversion at the elevation of our instruments.

The temperature conditions prevailing on the morning of the 13th were probably as extreme as ever occur here in April, and they should be easily overcome at small cost of labor and materials for smudging or heating. In the